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# WATER QUALITY OF MISKWABI LAKE IN RELATION TO SHORELINE DEVELOPMENT

Provisional County of Haliburton
Dudley Township

January 1976

Ministry of the Environment
Ontario

P.G. Cockburn, P.Eng.
Director
Central Region

Ontario

Ministry of the Environment

Central Region

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150 Ferrand Drive
Don Mills, Ontario
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Mr. G. H. Mills, Director,
Water Resources Branch

Dear Sir:

Please find enclosed a copy of our report entitled "Water Quality of Miskwabi Lake in Relation to Shoreline Development, Provisional County of Haliburton".

The study, which documents the existing water quality and projects the water quality impact of further development, was undertaken in response to a development proposal for the northern shore of the Lake.

The survey findings reveal that the general enrichment status of the Lake is favourably low, but the oxygen regime indicates that extra precaution will have to be taken to preserve the existing cold water fish habitat.

Attached is the initial distribution list for this report. Please contact this office, or the Muskoka-Haliburton District Office (705-687-3408) if you wish to suggest additions to this list, require additional copies, or have questions about the report.

Yours very truly,

P. G. Cockburn, P. Eng.,
Regional Director.

Attach.

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# WATER QUALITY
# OF MISKWABI LAKE
# IN RELATION TO
# SHORELINE
# DEVELOPMENT

Provisional County of Haliburton
Dudley Township

Report Prepared By
R. Shaw, Biologist
Technical Support Section

The Bacteriology Part of the Study (Field Evaluation and Report) was carried out by the Microbiology Section, Laboratory Services Branch of the Ministry of the Environment.

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## INTRODUCTION

A draft plan of subdivision (02-46T-74228) for ninety-four (94) shoreline lots on the northern shore of Miskwabi Lake was submitted to the Ministry of Housing in October 1974. This draft plan represented Phase 5 of a development scheme which encompassed Long and Miskwabi Lakes and Lake Wenona. The four previous phases of this development, which have been approved by the Ministry of Housing, resulted in three registered plans of subdivision within the drainage basin of Miskwabi Lake.

An environmental assessment submitted with the draft plan for Phase 5, classified Miskwabi Lake as oligotrophic. Information obtained from the Ministry of Natural Resources, indicated that the Lake presently supports a viable lake trout fishery. Considering;

a) the minimal water quality data available for the Lake,

b) the number of previously registered cottage lots within the Lake's drainage basin, and

c) the size of the proposed development,

the Ministry of Housing was informed, in 1974, that a water quality study of the Lake would be required, to enable the Ministry of the Environment to comment on the water quality implications of the proposed development. The present report outlines the results of the study.

## DESCRIPTION OF THE STUDY AREA

Miskwabi Lake, or Lake Miskwabinish, is located in Dudley Township, Provisional County of Haliburton. The Village of Haliburton, the nearest population

centre, is approximately fourteen (14) kilometers west of the Lake (Figure 1).

Miskwabi Lake is located in the Pre-cambrian Shield physiographic region which is characterized by granitic bedrock with thin overburden. The topography of the drainage basin is steep, to gently rolling hills, with a maximum elevation of approximately 80 m. above the level of Miskwabi Lake.

The Lake's physical characteristics are tabulated below:[1]

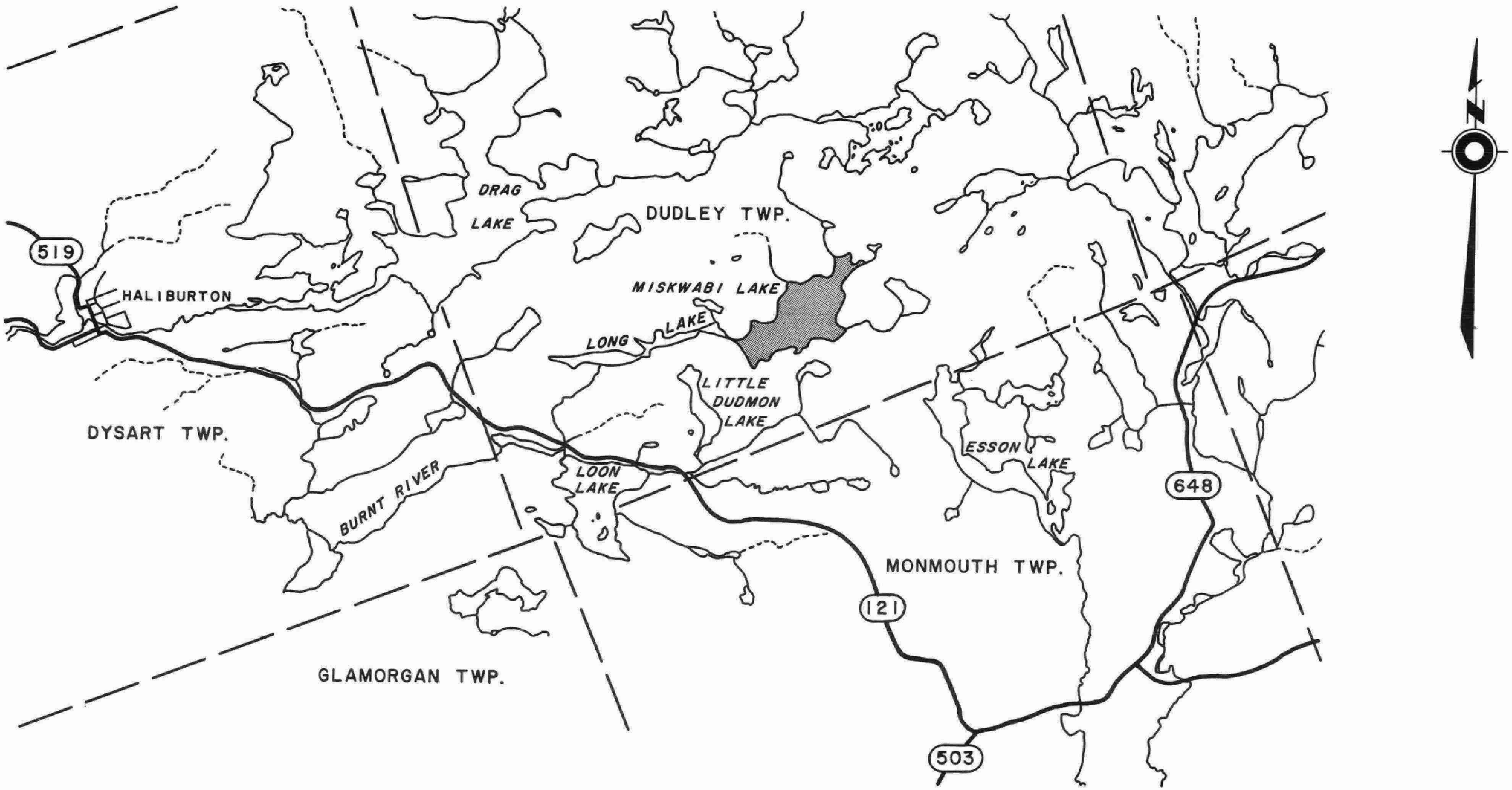
| | |
|---|---|
| Surface area | 2.68 $km^2$ |
| Maximum depth | 45 m |
| Mean depth | 19.1 m |
| Volume | $51.5 \times 10^6 m^3$ |
| Drainage basin area | 10.5 $km^2$ |

The small drainage basin area in relation to the area of the Lake results in a flushing rate of approximately 0.098 $yr^{-1}$ (i.e. the flushing time is 10.2 years), using a calculated lake outflow of $5.03 \times 10^6\ m^3\ yr.^{-1}$.[2]

Miskwabi Lake is a headwater lake on the Burnt River system (Figure 1) and, as such, is used as a storage reservoir for the Trent Canal System. Water movement is from Miskwabi Lake into Long Lake, then to the Burnt River which eventually empties via the Rosedale River into Cameron Lake on the Trent System. Flow is regulated by a control dam on the Burnt River outlet from Long Lake. The lake level (Miskwabi + Long) was dropped 4.3 feet between June 20th and October 14th of this year (Trent-Severn Waterways).

1. Ministry of Natural Resources
2. Dillon

FIGURE 1 - GEOGRAPHIC LOCATION OF MISKWABI LAKE

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Four inlets were noted during the study (Figure 3); two in the north bay of the Lake, which originate from small unnamed lakes, one on the east shore, also originating from an unnamed lake, and one on the north-west shore which originates in a swampy area. Flow was minimal in all four inlets, and virtually absent by late summer.

There are presently three registered plans of subdivision within Miskwabi Lake's drainage basin (Figure 2). The number of cottage lots involved is tabulated below:

| Registered Plan # | Total # of Lots | Number of Lots Within Miskwabi Lake's Drainage Basin |
|---|---|---|
| 482 | 165 | 56 |
| 484 | 102 | 68 |
| 516 | 80 | 80 |

There is a total of 204 approved cottage lots within the Lake's drainage basin, of which 115 are shoreline lots. Cottages had been built in 63 of these lots at the time of the survey.

## SURVEY PROCEDURES

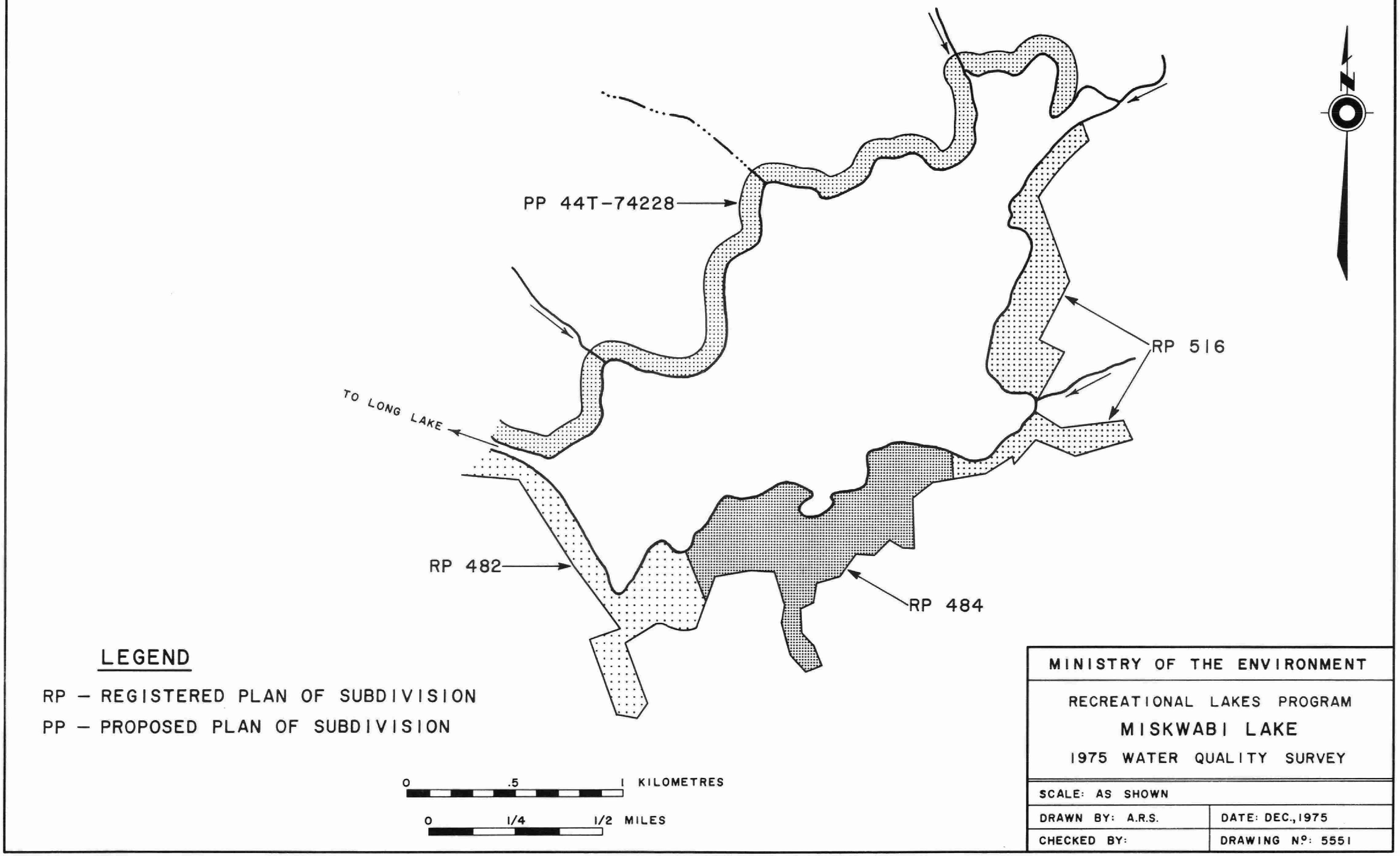
### Chemical and Biological

Three stations on the Lake were sampled on twelve separate occasions from May 13th to September 23, 1975 (Figure 3):

1. Station 3 - outlet station located in the channel leading to Long Lake

2. Station 6 - lake station located in the center of the Lake's major basin. Depth - 45 m.

FIGURE 2 - REGISTERED AND PROPOSED PLANS OF SUBDIVISION, MISKWABI LAKE



3. Station 13 - lake station located in the center of the Lake's secondary basin. Depth - 18 m.

The following activities were conducted during each visit to the two lake stations:

a) temperature and dissolved oxygen profiles were recorded using an EIL Model 15A dissolved oxygen meter, which was calibrated prior to each run using the azide modification of the Winkler method. Additionally, the dissolved oxygen concentrations in a surface and bottom (1 m off bottom) water sample were determined using the Winkler method to verify the meter's readings.

b) water transparency was measured using a Secchi disc (30 cm. diameter disc divided into alternative black and white quadrants).

c) samples for mineral, nutrient and chlorophyll a determinations were secured as composites through the euphotic zone (calculated as twice the Secchi disc depth). This was accomplished by lowering and raising a 800 ml bottle through the predetermined depth of the euphotic zone at a rate allowing complete filling as the bottle was retrieved to the surface. The chlorophyll a samples were treated with 1 ml of a 2% suspension of magnesium carbonate. If these samples could not be delivered to the MOE lab within 24 hours, the samples were filtered using a 1.2 u millipore filter, and stored in plastic containers until Lab delivery.

d) samples for mineral and nutrient determinations were taken 1 m off the bottom using a Van Dorn bottle.

A grab sample was collected at the outlet station, during each visit, for mineral and nutrient determinations.

Chemical analyses performed on each water sample included total and soluble phosphorus, Kjeldahl, nitrate,

free ammonia and nitrite nitrogen, total iron, alkalinity and hardness, conductivity, pH and colour. All chemical analyses including chlorophyll a determinations were done according to standard techniques utilized by the Water Quality Section, Laboratory Branch, MOE.

## Bacteriological

### Timing

Bacteriological surveys were carried out from May 30 to June 3, and July 25 to July 29. These 5-day sampling periods, during which samples were collected daily at many lake stations, provide a fairly accurate bacteriological picture of the Lake.

### Selection of Sample Locations

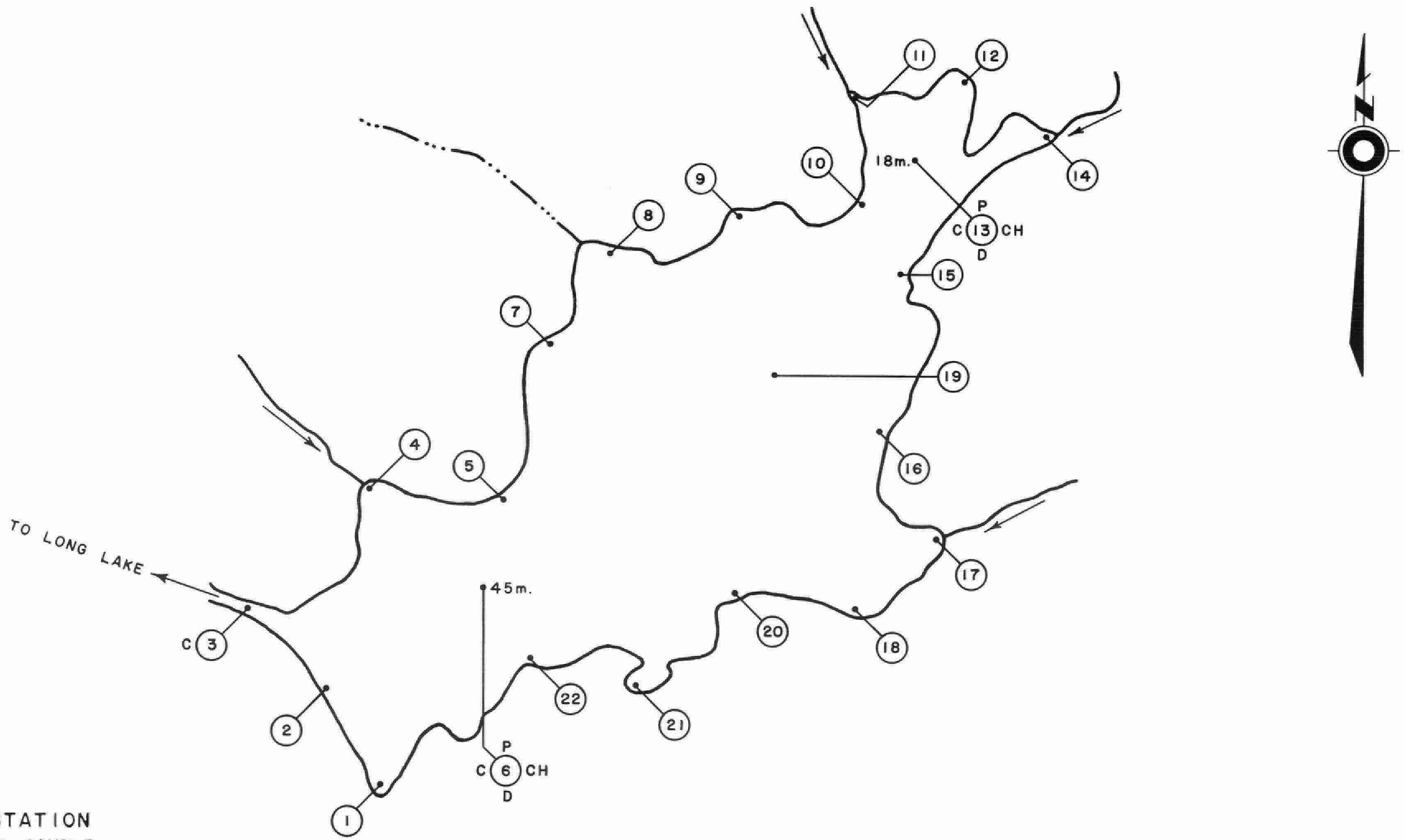
Bacteriological samples were collected from the outlet, the 4 inlets and 3 open-lake stations in addition to 19 shoreline locations considered to be representative of the various degrees of shoreline development found on the Lake (Figure 3). Samples were taken one meter below the surface at all stations, as well as one meter above the bottom at two of the open-lake stations (Stns. 6 and 13).

### Bacteriological Tests and Interpretation

The number of bacteria in each of the four types of "indicator" organisms was determined on each sample*. The four bacterial types-total coliform, fecal coliform, fecal streptococcus bacteria, and *Pseudomonas aeruginosa*, are all indigneous to man and other warm-blooded animals, and are found in the colon and feces in tremendous numbers. Many diseases common to man can be transmitted

*Methodology used is available upon request from the Microbiology Section, Laboratory Services, MOE.

FIGURE 3 - SAMPLING STATION LOCATIONS, MISKWABI LAKE




LEGEND

P
C (8) CH — SAMPLING STATION
D

C — CHEMICAL SAMPLE
P — PROFILE
CH — CHLOROPHYLL SAMPLE
D — DEPTH STATION
BACTERIOLOGICAL SAMPLES TAKEN AT ALL STATIONS

0 .5 1 KILOMETRES

0 1/4 1/2 MILES

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by feces; consequently, the probability of occurrence of these diseases is highest in areas where the water is contaminated with fecal material. These indicator organisms in water connote the possible presence of disease causing organisms.

In addition, the density of heterotrophic bacteria, those bacteria which require some organic carbon for growth, was determined at five locations considered to be representative of the whole lake. The density of heterotrophic bacteria varies in proportion to the trophic status of the lake (1, 3).

These data were evaluated by statistical techniques in the following manner. The geometric mean, the most appropriate central value, and standard deviation were calculated for the values of each of the three bacterial types at every station, providing concise valid data. Statistically significant variations in the bacterial densities between stations, or groups of stations was determined by a One Way Analyses of Variance and Bartlett's Test of Homogeneity. By these means the data from each station were tested against that of every other station until all stations with similar geometic mean densities were separated into groups (Group A).

The group results and those for individual stations, were identified by different stippling. Within each stippled area the group geometric mean applied for each type of bacteria, unless otherwise indicated by individual station values. The areas of better or worse bacterial densities were defined by the group geometric mean densities, and so any inputs of bacterial contamination, and the area they affect, were identified.

## EXISTING WATER QUALITY

All of the field data obtained, with the exception of temperature, dissolved oxygen, and bacteria, are outlined in Tables 1 to 5. The water quality measurements from Station 6 are considered to be representative of the overall Lake quality.

### Temperature and Light Characteristics

A well defined thermocline characterized both lake stations during the study, except on the first sample run on May 13. The thermal properties of the Lake, as characterized by measurements from Station 6, compare favourably to a first class lake of Hutchinson (4).

Fluctuation in the degree of transparency, as determined via a Secchi disc, were noted during the course of the survey, in addition to a minor variation between the two lake stations. The following table summarizes the Secchi disc readings.

| | Secchi Disc Reading (m) | | |
|---|---|---|---|
| | readings | range | mean |
| Station 6 | 5.5-10.2 | 4.7 | 7.7 |
| Station 13 | 5.5-9.0 | 3.5 | 7.0 |

The 4.7 m. range in the transparency measurements at Station 6 theoretically reflects a two fold change in algal density. A variation of this magnitude is not unusual considering the fluctuations in algal growth patterns. The difference in mean Secchi disc readings between the two lake stations is not significant, and the mean value from Station 6 has been taken to be representative of the Lake in general.

The colour of euphotic zone water samples was 10 Hazen units or less, which would have minimal affect on the

degree of transparency.

The euphotic zone, delineated by twice the Secchi disc depth, extended through the metalimnion and into the hypolimnion on all sampling occasions.

## Water Chemistry Characteristics

Alkalinity, hardness and conductivity values of 30 mg/l as $CaCO_3$, 40 mg/l as $CaCO_3$ and 87 umhos/$cm^3$ respectively are indicative of a typical soft water, Pre-Cambrian lake, with a weak bi-carbonate buffering system.

A slightly more basic pH prevailed throughout the euphotic zone (7.4 pH units) than 1 meter off bottom (7.0 pH units). In general, the pH of the Lake was very close to neutrality.

## Dissolved Oxygen

Station 6 of Miskwabi Lake was characterized by a positive heterograde dissolved oxygen curve through the metalimnion, which assumed a clinograde character in the hypolimnion (Figure 4). The minimum hypolimnetic dissolved oxygen concentration, measured during this study was 3.4 mg/l on September 23.

The character of the dissolved oxygen profile at Station 13 was similar to that of Station 6, though less pronounced. The minimum hypolimnetic dissolved oxygen concentration measured at this station was 5.3 mg/l on September 23.

## Nutrient Characteristics

The following table summarizes the total phosphorus concentration measured at the two lake stations.

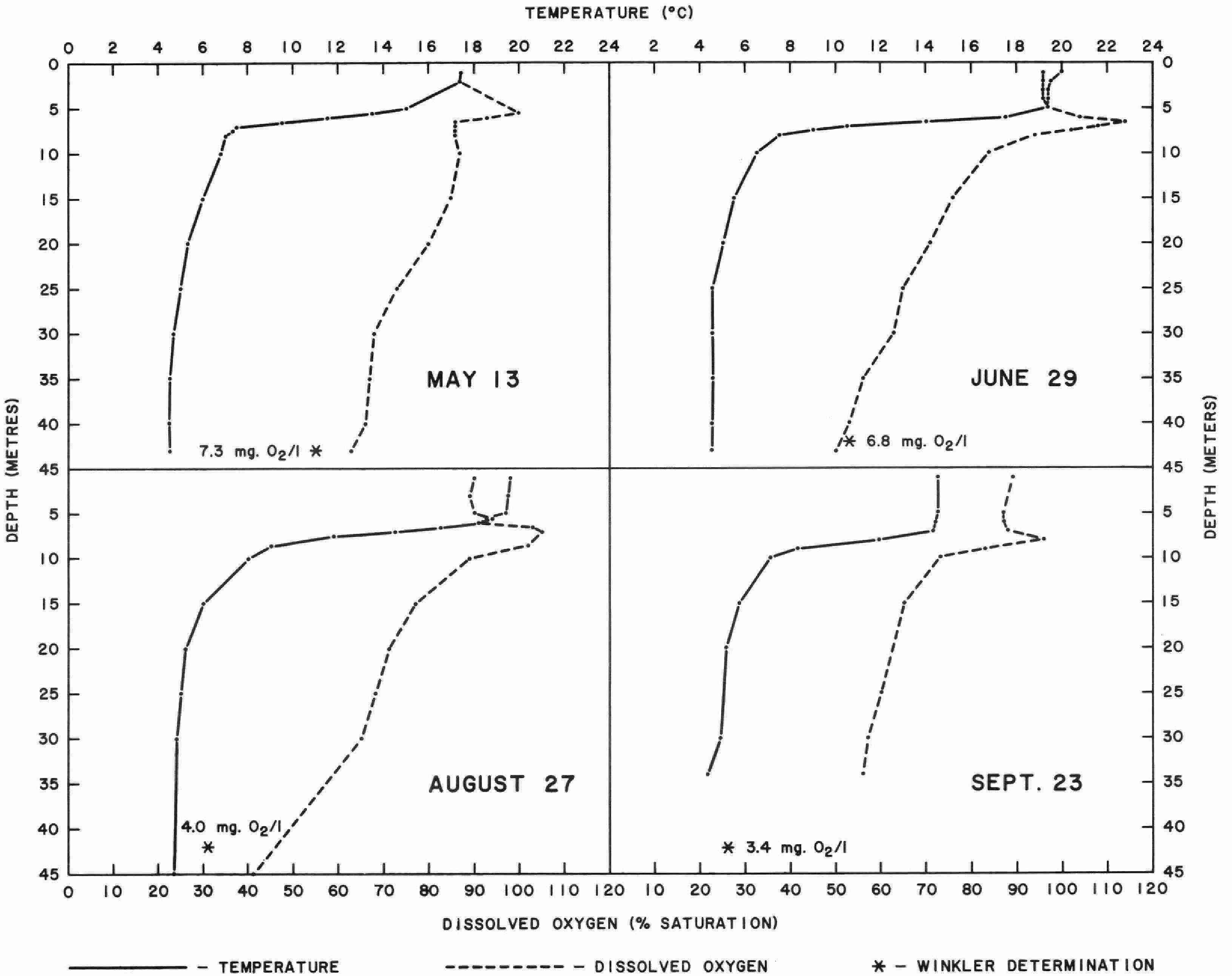



FIGURE 4 – DISSOLVED OXYGEN AND TEMPERATURE PROFILES, STATION 6, MISKWABI LAKE

| | Euphotic Zone [P] ug/l | | Bottom Waters [P] ug/l | |
|---|---|---|---|---|
| | mean | range | mean | range |
| Station 6 | 5.4 | 2-12 | 21 | 6-50 |
| Station 13 | 7.6 | 3-15 | 14 | 4-31 |

The mean euphotic zone concentration for Miskwabi Lake was lower than that measured for many other oligotrophic Pre-Cambrian lakes e.g. Lake Joseph (1969-70) - 8.2 ug/l, Lake Rosseau (1969-70) - 7.7 ug/l and Skeleton Lake (1972) - 9.0 ug/l.

Figure 5 illustrates the concentrations of phosphorus (total and soluble) at the two lake stations. It would appear that during the latter part of the summer period, there is some increase in the concentration of phosphorus near the bottom of the Lake, with the concentration of total P reaching 50 ug/l in the latter part of September.

The concentration of Kjeldahl nitrogen was low (0.23 mg/l as N) and remained relatively constant through the Lake during the study.

Euphotic zone inorganic nitrogen concentrations were low, with the $NH_3$-N and $NO_2$-N concentrations frequently at or below the analytical limits of detection (10 ug/l and 1 ug/l respectively).

The $NO_3$-N concentrations in the bottom waters were higher than the euphotic zone, and both lake stations exhibited a pronounced increase from July 29th to the end of the study e.g. Station 6:0.17-0.30 mg $NO_3$-N/l.

<u>Chlorophyll a</u>

Algal densities, as measured by chlorophyll <u>a</u> concentrations, were low, ranging from 0.8 to 4.4 ug/l, and having

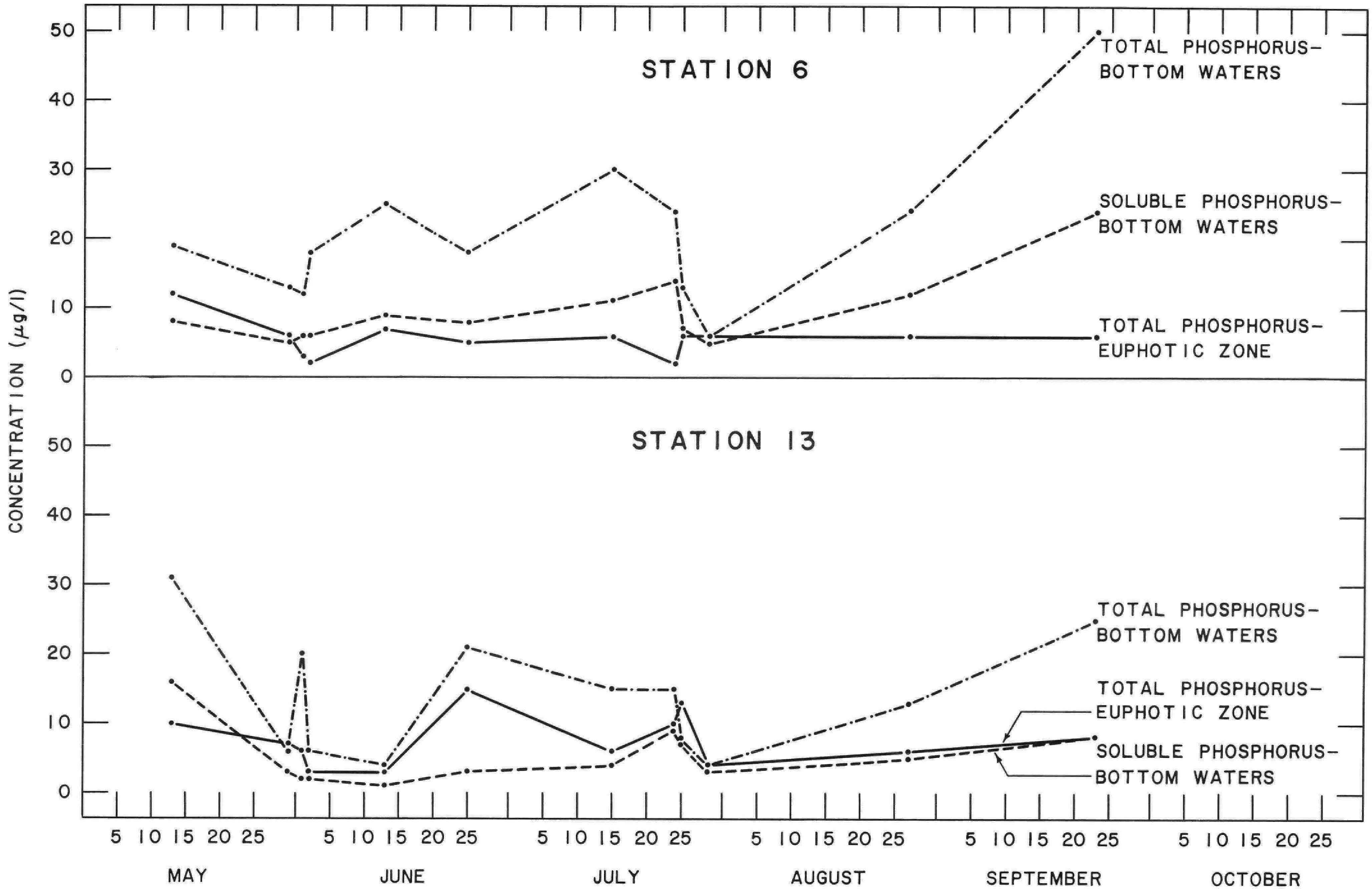



FIGURE 5 - PHOSPHORUS CONCENTRATIONS AT STATIONS 6 AND 13, MISKWABI LAKE

a mean of 1.6 ug/l for the Lake overall. Experience has indicated that lakes with chlorophyll a concentrations of less than 2 ug/l can be considered oligotrophic, or of low enrichment status.

## Bacteriology

During the June and July surveys, the bacteriological water quality of the main body of Miskwabi Lake was good, and well within the M.O.E. microbiology criteria for total body contact recreational use which states:

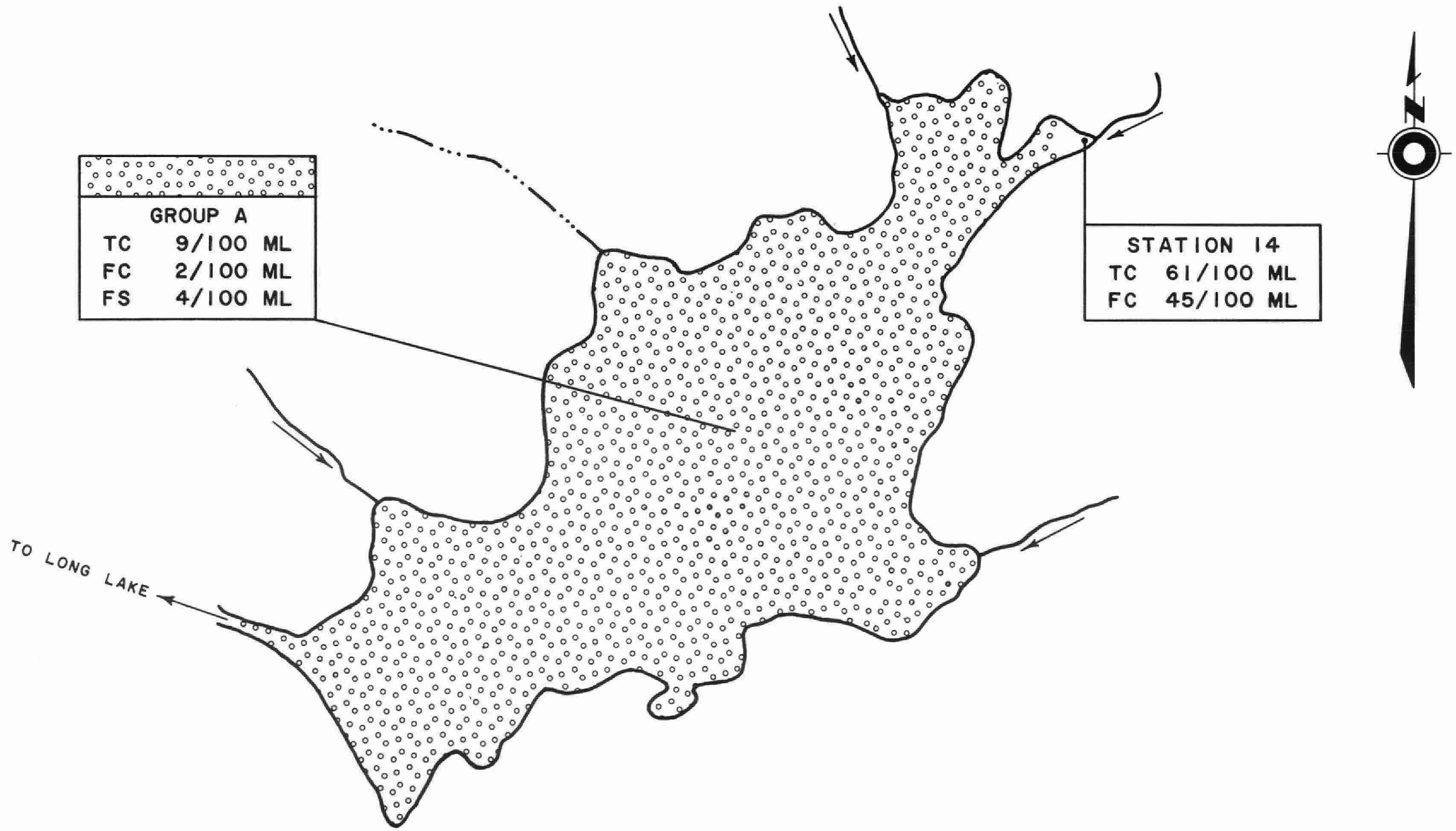
> "Where ingestion is probable, recreational waters can be considered impaired when the coliform (T.C.), fecal coliform (F.C.), and enterococcus (fecal streptococcus, F.S.) geometric mean density exceeds 1000, 100 and/or 20 per 100 ml. respectively, in a series of at least ten samples per month, including samples collected during weekend periods."[1]

In the June survey, the geometric mean bacterial densities for the main body of water was 9 T.C., 2 F.C., and 4 F.S. per 100 ml. (Group A, Figure 6). The only location which showed bacterial densities higher than Group A was at the mouth of an eastern inflowing stream where the geometric mean densities were 61 T.C. and 45 F.C. per 100 ml. The fecal streptococcus density at this location was 21/100 ml., and the fecal coliform to fecal streptococcus ratio of 2:1 indicated that the contamination was probably of animal origin,[2] but some human contamination could not be ruled out. The bacterial levels at this location were much higher than those of the main body of water, and some hazard to bathers was probably present, but the mouth of this stream was not likely used for recreational purposes.

[1] Guidelines and Criteria for Water Quality Management in Ontario.

[2] Water Quality Guidelines for Bathing Beaches, Ministry of Health 1975.

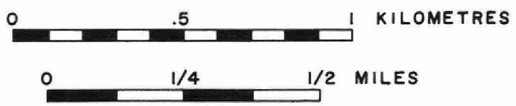
FIGURE 6 - DISTRIBUTION OF BACTERIA FOR THE MAY 30 TO JUNE 3 SURVEY




LEGEND

| GROUP OR STATION |
| --- |
| TC GM/100 ML |
| FC GM/100 ML |
| FS GM/100 ML |

GM - GEOMETRIC MEAN

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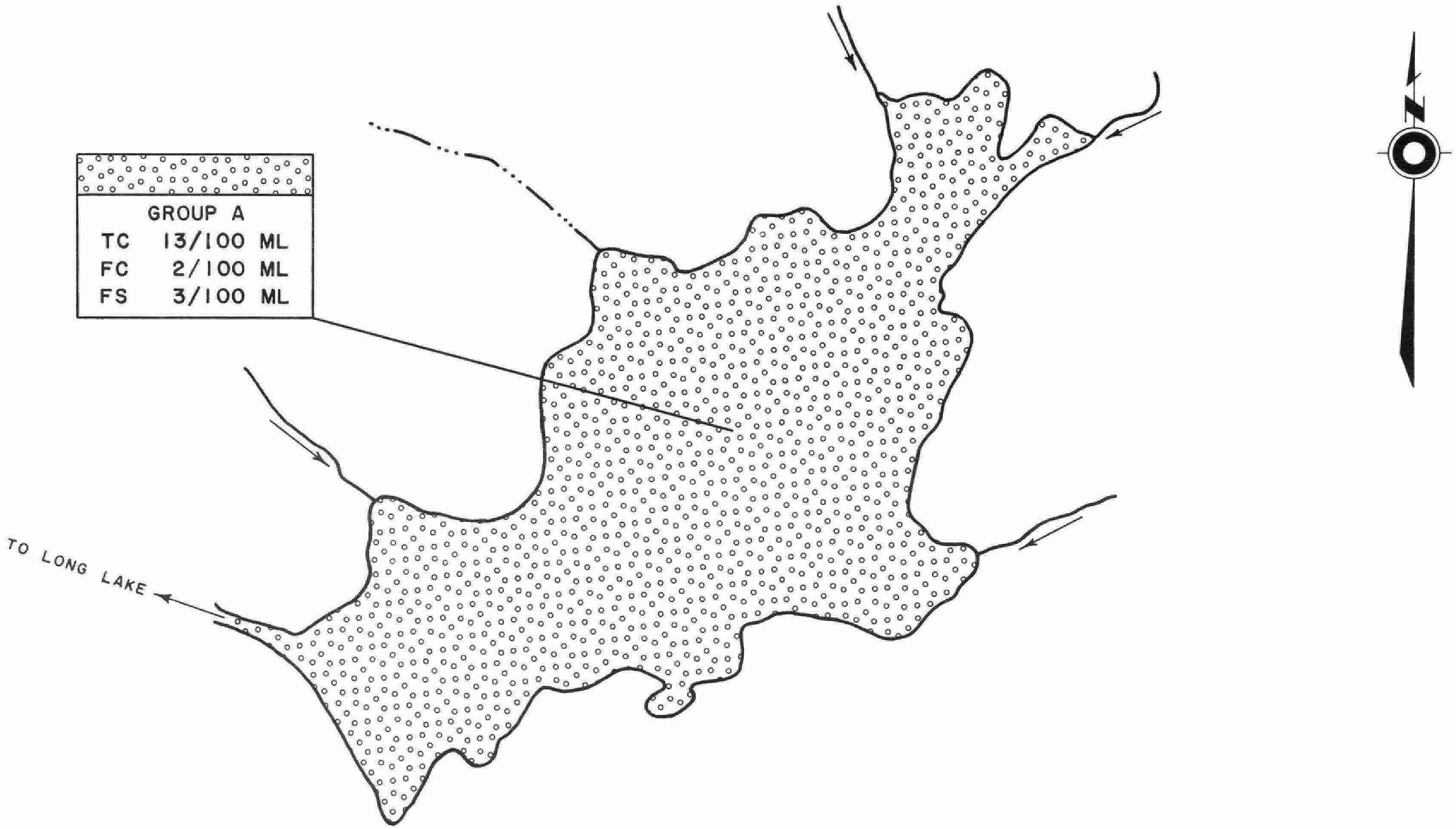
Inflows usually have higher bacterial levels than the rest of the lake as they can carry materials such as soil, decaying matter and possibly animal and human wastes into the lake. It was concluded that the contamination at this location was minimal, as it did not appear to have noticeable effects on the surrounding areas.

The geometric mean densities in the July survey were homogenous for the entire lake with concentrations of 13 T.C., 2 F.C. and 3 F.S. per 100 ml (Figure 7). Low levels of Pseudomonas aeruginosa were found at a few locations in the June survey but were detected at only one location (Stn. 7) in the July survey. The geometric mean density of aerobic heterotrophic bacteria in June was 558 per ml. and in July were similar with a value of 538 per ml. A relationship has been established between the heterotrophic bacterial densities in water and the trophic status of several lakes studied by the M.O.E. in 1974(3). Miskwabi Lake lies at the lower end of this curve along with other oligotrophic lakes. (Figure 8)

It has often been observed that following a rainfall, bacterial levels increase and may remain elevated for a few days. A rainfall effect is measured by an increase in fecal coliform levels, following a rainfall, of greater magnitude than daily variations. In the July survey daily changes in mean fecal coliform densities were small, but rose abruptly following a heavy rainfall (Figure 9). This rainfall effect was large as it affected the main body of the lake as well as the inflowing streams. A total of 1.0 inch of rain was recorded in a rainfall gauge on the shore of the lake, and it appeared that many bacteria were washed out of the surrounding soil into the lake. The daily geometric mean densities for the July 29th were 41 F.C. and 2 F.S. per 100 ml. for the main body of water. The bacterial contamination washed in by rain could have been of human origin for

FIGURE 7 - DISTRIBUTION OF BACTERIA FOR THE JULY 25 TO JULY 29 SURVEY




## LEGEND

| GROUP OR STATION |
|---|
| TC GM/100 ML |
| FC GM/100 ML |
| FS GM/100 ML |

GM — GEOMETRIC MEAN

0 .5 1 KILOMETRES

0 1/4 1/2 MILES

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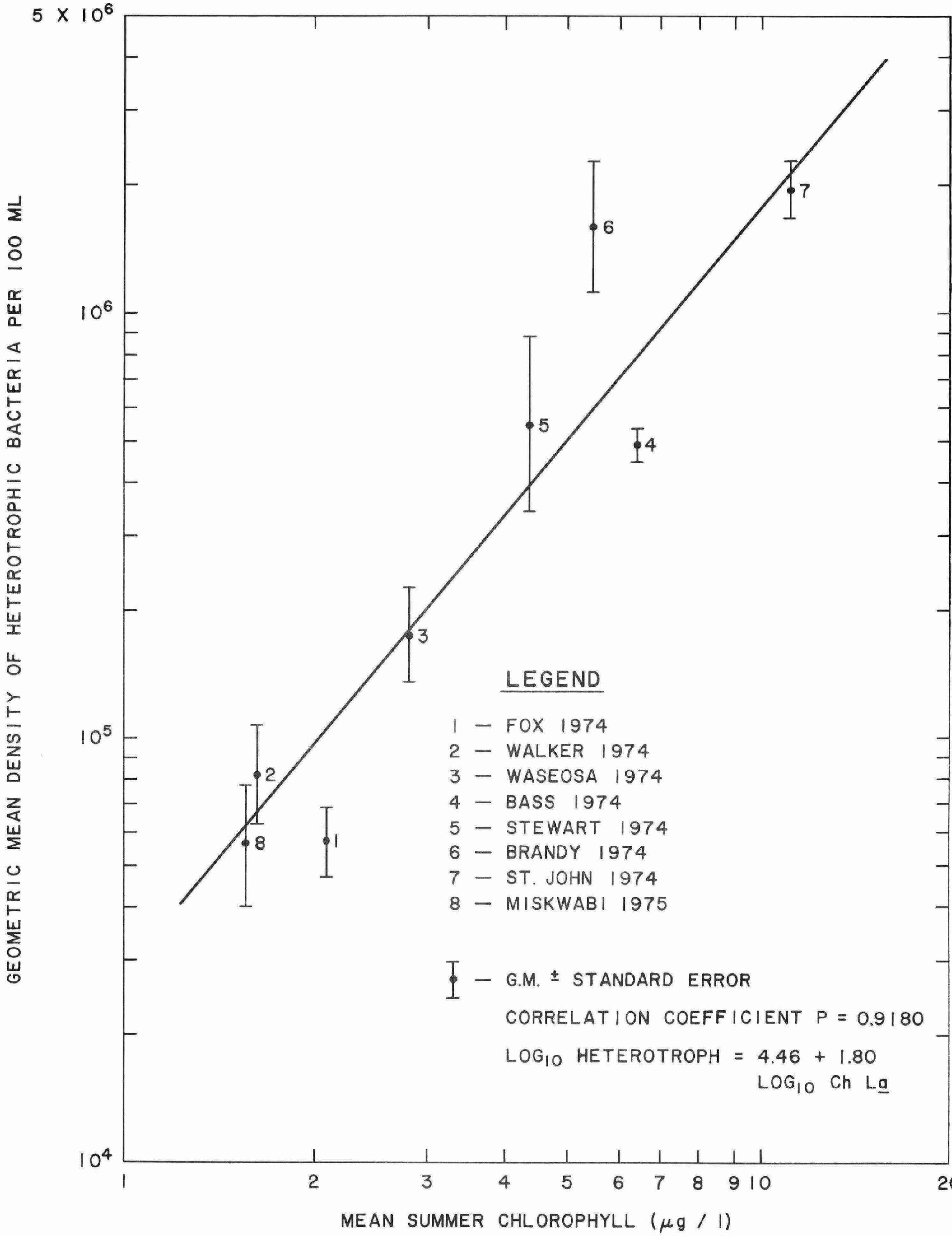
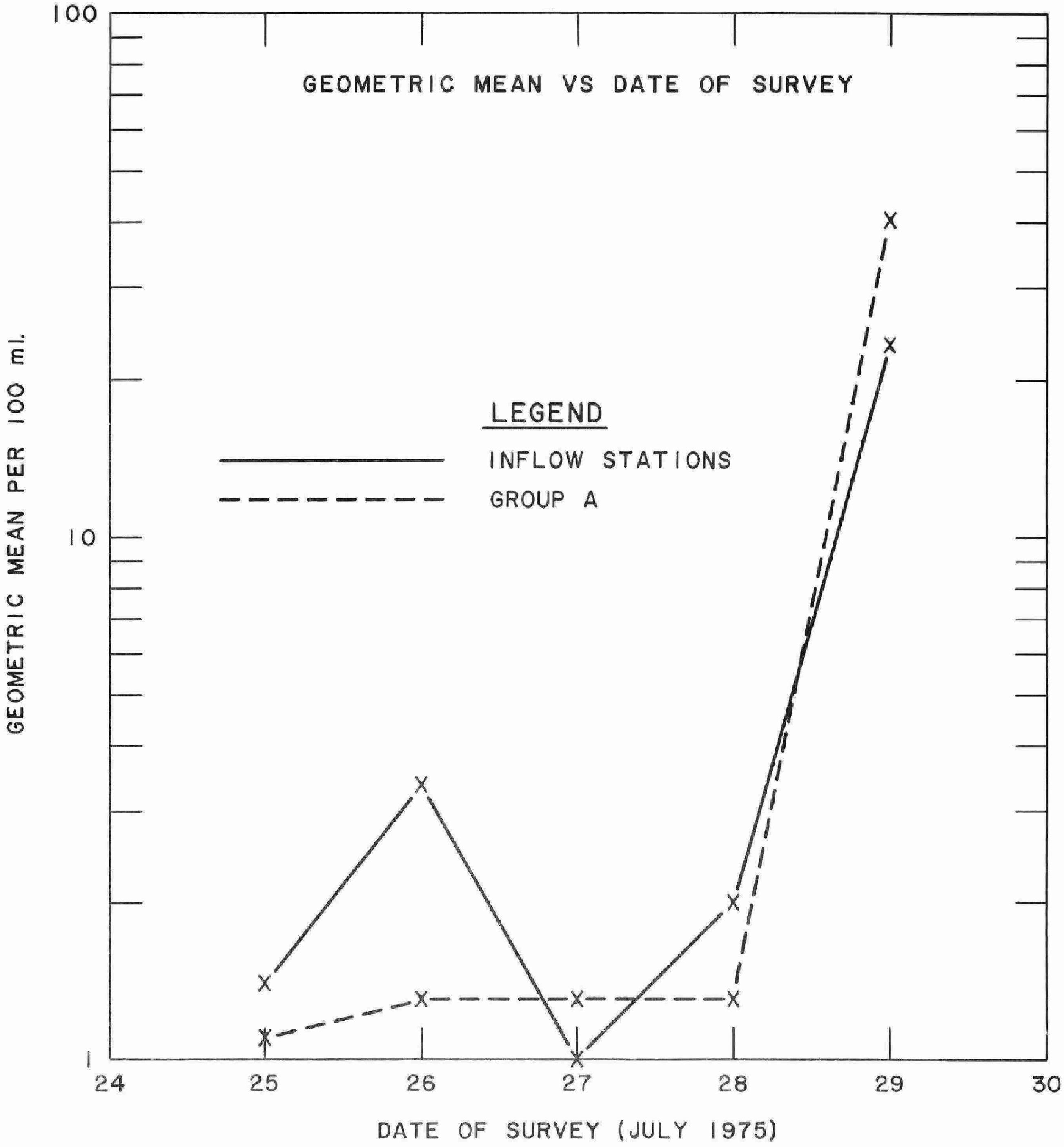
FIGURE 8 — COMPARISON OF LAKES - SPRING HETEROTROPHIC BACTERIAL DENSITY IN SURFACE WATERS VS TROPHIC STATUS





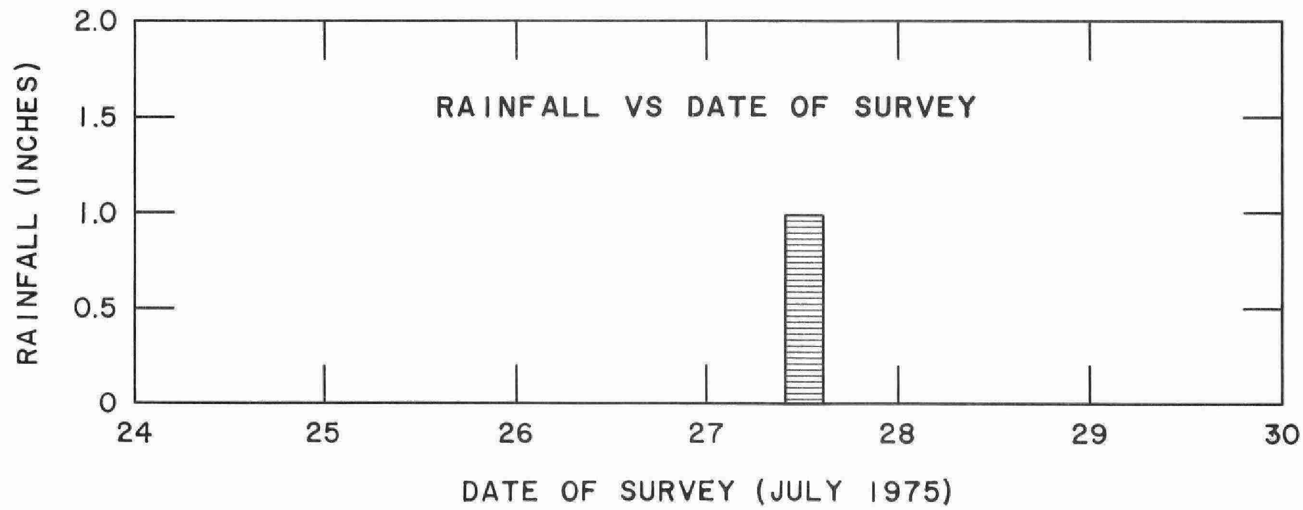




FIGURE 9 - DAILY FECAL COLIFORM GEOMETRIC MEAN DENSITY

the FC:FS ratio of 20 was very high. A major source of bacteria after rainfall was the mouth of the eastern stream (STN. 14) where greater than 1,200 FC per 100 ml. were found.

The pattern of bacterial distribution found in the two surveys was similar. There was a slight increase in total coliform densities and a slight decrease in fecal streptococcus densities in July.

## Effect of Present Development on the Lake

The effect of present development on the lake has been demonstrated by these surveys. The effect on the mean densities for the main portion of the lake was not great for they were not greater than those found in an undeveloped lake (5). A large source of indicator bacteria was rainfall runoff, which washed in fecal bacteria probably of human origin, which were detected in the entire lake. This rainfall effect becomes more pronounced as lakes are developed, and was not observed in an undeveloped lake (5).

The effect of future development on the lake cannot be calculated accurately at present, however, the lake has responded to present development and further development must increase this response.

## Overall Water Quality Status

The general status of a clear water lake, and a comparison with other lakes can be readily obtained by plotting the mean values for chlorophyll a and Secchi disc readings on a graph which has been derived by staff of the Ministry of the Environment, relating these two parameters. Figure 10 illustrates the position of Miskwabi Lake relative to a number of other lakes in both the Pre-Cambrian and sedimentary areas of the Province. Miskwabi Lake compares favourably to other previously surveyed oligotrophic water bodies such as Lake Joseph, Lake Rosseau and Skeleton Lake.

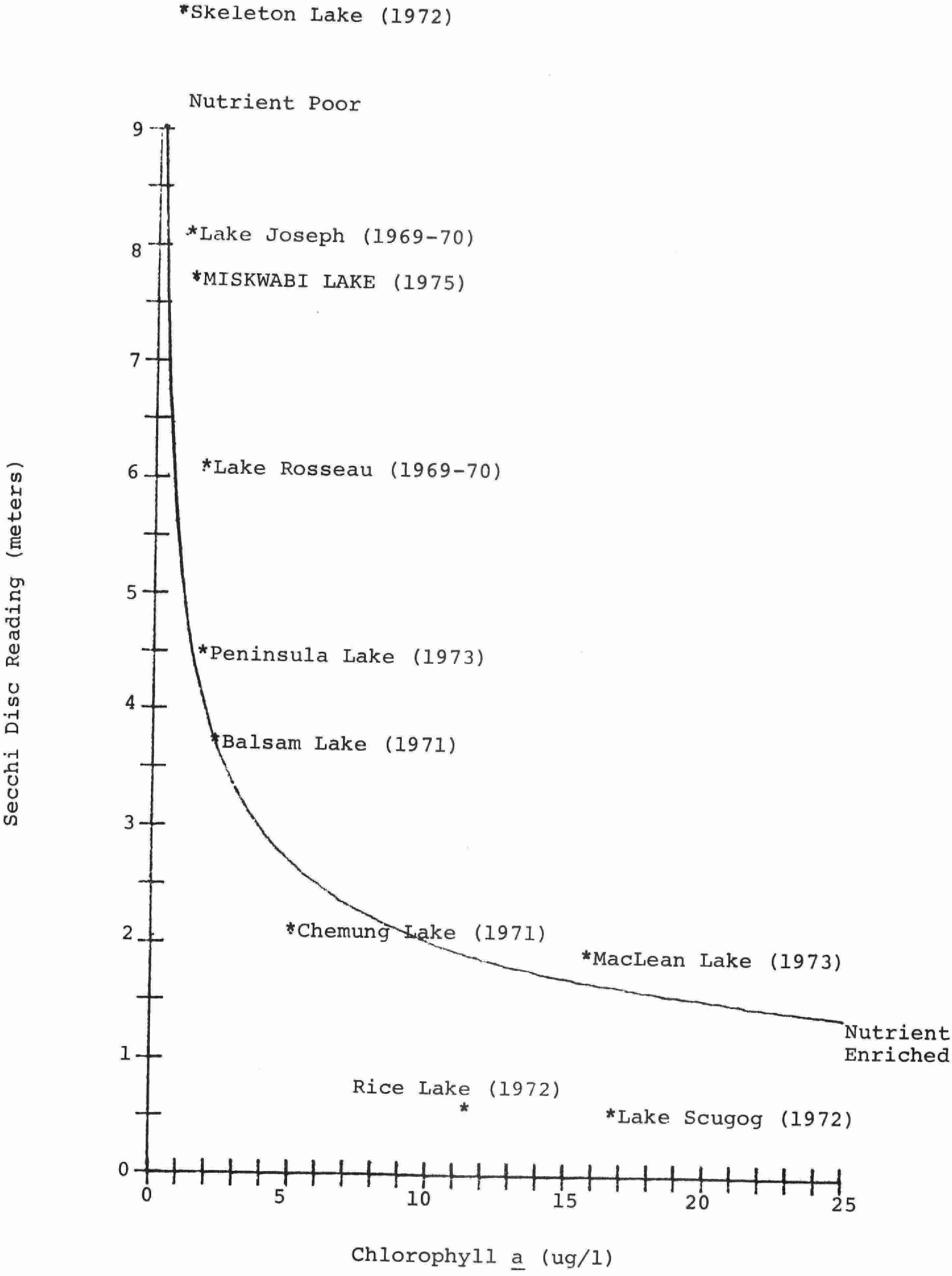



Figure 10 Mean Chlorophyll a and Secchi Disc Measurements in Miskwabi Lake, Relative to Other Ontario Lakes.

Generally, in assessing the status of a lake, it can be considered oligotrophic if:

1) the mean Secchi disc reading for the ice free period is greater than 5.0 meters;

2) the mean euphotic zone total phosphorus concentration for the ice free period is less than 10 ug/l;

and

3) the mean chlorophyll a concentration for the ice free period is less than 2.0 ug/l.

Miskwabi Lake is therefore oligotrophic.

Typically, oligotrophic lakes provide suitable habitat for cold water fish species, contain nutrients in concentrations which are not sufficient to support nuisance growths of algae or aquatic weeds, and exhibit a high degree of transparency. Miskwabi Lake displays all these characteristics, however, the following signs of eutrophication are also present:

1) The bottom water dissolved oxygen concentration at Station 6 was depressed from 9.7 mg/l on May 13 to 3.4 mg/l on September 23;

2) there appeared to be some accumulation of phosphorus, in the latter part of the summer, in the bottom waters at Station 6.

Miskwabi Lake, due to its morphometry, is the most sensitive of lake types to additional nutrient inputs. Increasing the nutrient input to the Lake will increase the productivity, resulting in further depression of the bottom water's dissolved oxygen concentrations.

# EFFECT OF FURTHER SHORELINE DEVELOPMENT ON WATER QUALITY

Presently, only one mathematical model exists, which enables the existing water quality of a lake to be computed. It can also be used to determine the water quality impact of further development within the drainage basin. This methodology is outlined in the M.O.E. publication by Dr. P. Dillon "A Manual For Calculating the Capacity of A Lake Development", March 1975.

Although this manual has received wide acceptance, it must be recognized as a theory which attempts to mathematically define a complex system.

The following calculations were completed using the procedure outlined in the Manual, plus the modifications that will appear in its next edition (P.J. Dillon, pers. comm.)

The following factors remain constant for all determinations using the Manual.

$Ao = 2.68 \times 10^6 m^2$

$\bar{z} = 19.1$ m

$V = 51.5 \times 10^6 m^3$

$Q = 5.03 \times 10^6 m^3/yr$

$p = Q/V = 0.098$ times/yr

$q_s = Q/A_o = 1.88 m/yr$

$R = 13.2/(13.2 + qs) = 0.875$

$Ad = 10.5 \times 10^6 m^2$

$J_E = (5.5\ mg/m^2/yr)(10.5 \times 10^6 m^2) = 58\ kg/yr$

$J_{PR} = (38\ mg/m^2/yr)(2.68 \times 10^6 m^2) = 102\ kg/yr$

$J_N = 102 + 58 = 160$ kg total P/yr

Prior to utilizing the Manual to predict the impact of further development within Miskwabi Lake's drainage basin, the Manual's determination of the existing water quality, was compared to that measured during this study. This involved the following calculations:

$J_A = (63\ cottages)(0.77\ cap\text{-}yr/cottages/yr)(^*0.8\ kg/cap\text{-}yr)$

$= 39\ kg/yr$

$J_T = J_N + J_A = 199\ kg/yr$

$L = J_T/Ao = 74\ mg/m^2/yr$

$[P] = L(1-R)/\bar{z}p = 4.9\ mg/m^3$

$[chl\ \underline{a}] = 0.7\ mg/m^3$

$S.D. = 5.21[chl\ \underline{a}]^{-0.41} = 6.0m$

*This assumes that all septic tank effluent phosphorus reaches the lake. This is the extreme case; however, the Manual, due to a lack of data, does not recognize increased phosphorus inputs resulting from the removal of vegetation, road construction etc. Therefore the extreme case has been used in all calculations in an effort to account for those activities.

The following table compares the Manual's predictions, to that measured:

| | [P] ($mg/m^3$) | [Chl a] ($mg/m^3$) | S.D. (m) |
|---|---|---|---|
| Predicted | 4.9 | 0.7 | 6.0 |
| Measured(Stn. 6) | 5.4 | 1.6 | 7.7 |

The above comparison of phosphorus values is somewhat invalid, since the Manual predicts spring phosphorus concentrations (at spring circulation), whereas the measured represents the mean phosphorus concentration for the study.

Although the correlation for chlorophyll a concentrations and Secchi disc readings (S.D.) is reasonable, the Manual's prediction of existing water quality was not considered accurate enough to be used as a base for definitive predictions of future water quality values, resulting from further drainage basin development.

However, calculations, via the Manual, were completed to determine predicted water quality in the following two cases of development.

Case A - all existing registered shoreline lots within the drainage basin were developed (63 existing cottages + 52 lots = 115 cottages)

Case B - Case A + the 94 lot subdivision currently under consideration was developed (63 existing cottages + 52 registered shoreline lots + 94 proposed lots = 209 cottages)

This was done to obtain an indication of the degree of change that might be expected, given each case of development. The calculations are summarized below:

Case A

$J_A$ = (115 cottages)(0.77 cap-yr/cottage/yr)(0.8 kg/cap/-yr)

= 70.8 kg/yr

$J_T$ = 160 + 70.8 = 230.8 kg/yr

L = 86.1 mg/m$^2$/yr

$$[P] = \frac{86.1(.125)}{19.1(.098)} = 5.8 \text{ mg/m}^3$$

$[chl\ \underline{a}] = 0.9$ mg/m$^3$

S.D. = 5.4 m

<u>Case B</u>

$J_A$ = (209 cottages)(0.77 cap-yr/cottage/yr)(0.8 kg/cap-yr)

= 128.7 kg/yr

$J_T$ = 160 + 128.7 = 288.7 kg/yr

L = 107.7 mg/m$^2$/yr

$$[P] = \frac{107.7(.125)}{19.1(.098)} = 7.2 \text{ mg/m}^3$$

$[chl\ \underline{a}] = 1.3$ mg/m$^3$

S.D. = 4.7 m

The following table compares the measured water quality, the Manual's computed existing water quality and the Manual's predicted water quality for the two given cases of development.

| | [P]-mg/m$^3$ | [Chl $\underline{a}$]-mg/m$^3$ | S.D. - m |
|---|---|---|---|
| measured (Stn. 6) | 5.4 | 1.6 | 7.7 |
| computed-existing | 4.9 | 0.7 | 6.0 |
| predicted-Case A | 5.8 | 0.9 | 5.4 |
| predicted-Case B | 7.2 | 1.3 | 4.7 |

Examining the Manual's predicted degree of change, and by applying it to the measured water quality, the following table was derived:

| | [Chl a]-mg/$m^3$ | S.D. - m |
|---|---|---|
| measured (Stn. 6) | 1.6 | 7.7 |
| Case A | 2.1 | 6.9 |
| Case B | 3.0 | 6.0 |

These values are indicative of the expected water quality that will materialize from the two given cases of development. That is, development of all registered lots within Miskwabi Lake's drainage basin (Case A), is expected to cause a 10% depression of water transparency, and a 29% increase in chlorophyll a concentrations. Development of the proposed 94 lot subdivision, in addition to the already registered lots (Case B) is expected to cause a 22% depression of the existing water transparency, and a 86% increase in chlorophyll a concentrations.

## SUMMARY - CONCLUSIONS - RECOMMENDATIONS

1. The chemical, physical, and biological water quality of Miskwabi Lake is very good. The high degree of water transparency, low chlorophyll a concentrations typify an oligotrophic lake. There are, however, signs of eutrophication apparent; the bottom water dissolved oxygen concentration was depressed to 3.4 mg/l by late September, and accumulations of phosphorus in the bottom waters increased during the latter portion of the survey.

2. The bacteriological water quality of Miskwabi Lake in 1975 was good. In June bacterial contamination was found at the mouth of an inflowing stream (Stn. 14) where fecal bacteria of animal origin were found. A large rainfall effect was observed in July when fecal coliform levels rose abruptly after heavy rainfall. These bacteria may have had a human source. The levels of aerobic heterotrophic bacteria were low and corresponded to the low nutrient levels in the lake. The sensitivity of bacterial densities to rainfall was thought to be due in part to present development on the lake.

3. There are presently three registered plans of subdivision on Miskwabi Lake, totalling 204 lots within the drainage basin, of which 115 are shoreline lots. Sixty-three of these lots have been developed with cottages. The erection of cottages on the remaining 52 lakefront lots is expected to cause a 10% depression of existing water transparency and a 29% increase in existing chlorophyll a concentration. Due to Miskwabi Lake's sensitivity to increased nutrient inputs, this amount of change will manifest itself in further depletion of bottom water dissolved oxygen and increased nutrient concentrations in the lower stratum.

4. Approval of the proposed subdivision (46T-74228) and its subsequent development would be expected to promote a further 13% reduction in water transparency and an additional 44% increase in chlorophyll a concentrations. That is, development of the existing registered shoreline lots, plus the proposed subdivision would be expected to depress the existing degree of water transparency by 22% and increase the existing chlorophyll a concentration by 86%. Considering the Lake's sensitivity to increased nutrient inputs, and the existing cold water fish habitat, the Central Region of the Ministry of the Environment, at this time, does not support the approval of the proposed plan of subdivision (46T-74228) on Miskwabi Lake, nor any further development on the Lake. It is realized that development cannot be halted on the already registered lots.

5. It is recommended that any clearing operation on slopes adjacent to the Lake be minimized, and cottagers are urged to make sure existing disposal systems meet the current requirements of the Ministry of the Environment. Field observations made during this survey indicated that several existing cottage disposal systems did not meet these requirements. The installation of any new septic tank disposal systems should be in accordance with Ontario Regulation 229-74, Part VII, Environmental Protection Act S.O., 1971.

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TABLE 1: Analysis Results for Euphotic Zone Samples at Station 6

| Date | Secchi Disc-m. | Chor. a-ug/1 | Alk.-mg/1 | Hardness-mg/1 | Cond.-umhos/$cm^3$ | T-Iron-mg/1 | T-Phos.-ug/1 | S-Phos.-ug/1 | TKN-mg/1 | $NH_3$/N-mg/1 | $NO_2$/N-mg/1 | $NO_3$/N-mg/1 | pH | Colour-Hazen Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13/5/75 | 5.7 | 2.5 | 30 | 43 | 86 | .10 | 12 | 2 | .23 | .02 | .002 | .04 | 7.4 | 5 |
| 30/5/75 | 8.9 | 1.8 | 30 | 40 | 82 | .05 | 6 | 1 | .22 | .01 | .002 | .05 | 7.2 | 10 |
| 1/6/75 | 9.1 | 0.9 | 29 | 40 | 86 | *.05 | 3 | 2 | .16 | .02 | .002 | .06 | 7.2 | 10 |
| 2/6/75 | 10.2 | 1.2 | 29 | 40 | 88 | *.05 | 2 | 1 | .15 | .01 | .002 | .03 | 7.3 | 10 |
| 13/6/75 | 8.5 | 0.8 | 29 | 40 | 84 | *.05 | 5 | 1 | .23 | *.01 | .002 | .07 | 7.2 | 5 |
| 25/6/75 | 8.0 | 1.2 | 30 | 42 | 86 | .03 | 5 | *1 | .34 | .01 | .001 | .06 | 7.4 | 10 |
| 15/7/75 | 6.5 | - | 31 | 41 | 85 | - | 6 | 1 | .22 | *.01 | .001 | .08 | 7.5 | 5 |
| 24/7/75 | 6.5 | 1.4 | 30 | 36 | 86 | - | 2 | 1 | .18 | .01 | .001 | .04 | 7.4 | 5 |
| 25/7/75 | 5.5 | 1.7 | 30 | 39 | 89 | - | 6 | 2 | .21 | .01 | .001 | .03 | 7.5 | 10 |
| 29/5/75 | 7.0 | 2.5 | 30 | 39 | 86 | - | 6 | 3 | .30 | *.01 | .001 | .03 | 7.7 | 5 |
| 27/8/75 | 8.0 | 1.6 | 30 | 42 | 88 | - | 6 | 1 | .20 | .01 | .001 | .01 | 7.2 | 5 |
| 23/9/75 | 8.3 | 4.4 | 30 | 40 | 90 | .06 | 6 | 2 | .27 | *.01 | .001 | .01 | 7.5 | - |

*less than

TABLE 2: Analysis Results for Bottom Water Samples at Station 6

| Date | Alk.-mg/1 | Hardness-mg/1 | Conductivity umhos/cm$^3$ | T-Iron-mg/1 | T-Phos-ug/1 | S-Phos-ug/1 | TKN-mg/1 | $NH_3$/N-mg/1 | $NO_2$/N-mg/1 | $NO_3$/N-mg/1 | pH | Colour-Hazen Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13/5/75 | 30 | 42 | 88 | .20 | 19 | 8 | .21 | .01 | .001 | .03 | 7.0 | 10 |
| 30/5/75 | 30 | 40 | 88 | .10 | 13 | 5 | .18 | .02 | .001 | .10 | 7.2 | 10 |
| 1/6/75 | 29 | 40 | 86 | .15 | 12 | 6 | .17 | .01 | .002 | .11 | 7.2 | 15 |
| 2/6/75 | 30 | 40 | 88 | .15 | 18 | 6 | .20 | .03 | .002 | .12 | 7.1 | 15 |
| 13/6/75 | 29 | 40 | 86 | .20 | 25 | 9 | .25 | .01 | .003 | .18 | 6.9 | 10 |
| 25/6/75 | 30 | 40 | 88 | .08 | 18 | 8 | .22 | .01 | *.001 | .16 | 6.9 | 10 |
| 15/7/75 | 35 | 45 | 93 | - | 30 | 11 | .36 | .13 | .001 | .02 | 7.1 | 5 |
| 24/7/75 | 33 | 39 | 89 | - | 24 | 14 | .23 | .02 | .006 | .25 | 7.0 | 5 |
| 25/7/75 | 26 | 39 | 88 | - | 13 | 7 | .19 | .02 | .002 | .20 | 6.9 | 5 |
| 29/7/75 | 32 | 39 | 87 | - | 6 | 5 | .23 | .01 | .001 | .17 | 7.1 | 5 |
| 27/8/75 | 31 | 43 | 90 | - | 24 | 12 | .20 | .01 | .001 | .20 | 7.1 | 10 |
| 23/9/75 | 32 | 42 | 90 | .31 | 50 | 24 | .26 | .01 | .001 | .30 | 6.8 | - |

*less than

TABLE 3: Analysis Results for Euphotic Zone Samples at Station 13

| Date | Secchi Disc-m. | Chor. a-ug/1 | Alk.-mg/1 | Hardness-mg/1 | Conductivity umhos/cm$^3$ | T-Iron-mg/1 | T-Phos.-ug/1 | S-Phos.-ug/1 | TKN-mg/1 | $NH_3$/N-mg/1 | $NO_2$/N-mg/1 | $NO_3$/N-mg/1 | pH | Colour-Hazen Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13/5/75 | - | 2.8 | 30 | 43 | 88 | .10 | 10 | 2 | .21 | .03 | .002 | .04 | 7.2 | 5 |
| 30/5/75 | 9.0 | 0.6 | 29 | 40 | 85 | .05 | 7 | 1 | .20 | .01 | .002 | .05 | 7.3 | 10 |
| 1/6/75 | 7.5 | 1.7 | 29 | 41 | 86 | .05 | 6 | 2 | .25 | .01 | .002 | .06 | 7.1 | 10 |
| 2/6/75 | 6.5 | 1.3 | 29 | 40 | 88 | .05 | 3 | 1 | .24 | .01 | .002 | .08 | 7.3 | 10 |
| 13/6/75 | 7.0 | 0.9 | 29 | 41 | 86 | *.05 | 3 | 1 | .21 | *.01 | .002 | .08 | 7.2 | 10 |
| 25/6/75 | 9.5 | 1.0 | 30 | 40 | 86 | .04 | 15 | 3 | .25 | .03 | .002 | .07 | 7.1 | 10 |
| 15/7/75 | 6.5 | - | 31 | 41 | 86 | - | 6 | 1 | .22 | .02 | .001 | .07 | 7.4 | 10 |
| 24/7/75 | 6.0 | 2.8 | 31 | 39 | 86 | - | 10 | 3 | .24 | .02 | .001 | .05 | 7.3 | 5 |
| 25/7/75 | 5.5 | 3.0 | 28 | 39 | 86 | - | 13 | 2 | .22 | .02 | .002 | .04 | 7.3 | 5 |
| 29/7/75 | 6.5 | 2.2 | 30 | 39 | 87 | - | 4 | 2 | .27 | .01 | .001 | .04 | 7.4 | 5 |
| 27/8/75 | 6.0 | 1.7 | 30 | 41 | 86 | - | 6 | 1 | .20 | .01 | .001 | .01 | 7.2 | 5 |
| 23/9/75 | 7.5 | 1.9 | 30 | 40 | 90 | .08 | 8 | 1 | .26 | .01 | .001 | .01 | 7.6 | - |

*less than

TABLE 4: Analysis Results for Bottom Water Samples at Station 13

| Date | Alk.-mg/1 | Hardness-mg/1 | Conductivity umhos/$cm^3$ | T-Iron-mg/1 | T-Phos-ug/1 | S-Phos-ug/1 | TKN-mg/1 | $NH_3$/N-mg/1 | $NO_2$/N-mg/1 | $NO_3$/N-mg/1 | pH | Colour-Hazen Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13/5/75 | 33 | 43 | 93 | .30 | 31 | 16 | .25 | .01 | .001 | .08 | 7.0 | 10 |
| 30/5/75 | 29 | 40 | 86 | .05 | 6 | 3 | .18 | .02 | .001 | .07 | 6.8 | 10 |
| 1/6/75 | 31 | 40 | 86 | .15 | 20 | 2 | .32 | .01 | .002 | .08 | 7.1 | 5 |
| 2/6/75 | 29 | 40 | 88 | *.05 | 6 | 3 | .18 | .02 | .002 | .09 | 7.2 | 10 |
| 13/6/75 | 29 | 41 | 86 | *.05 | 4 | 1 | .21 | *.01 | .002 | .13 | 7.1 | 20 |
| 25/6/75 | 30 | 40 | 86 | .10 | 21 | 3 | .31 | .02 | .002 | .13 | 7.1 | 5 |
| 15/7/75 | 31 | 41 | 87 | - | 15 | 4 | .24 | .07 | .001 | *.01 | 7.3 | 5 |
| 24/7/75 | 32 | 39 | 88 | - | 15 | 9 | .25 | .04 | .001 | .15 | 7.1 | 8 |
| 25/7/75 | 29 | 39 | 87 | - | 8 | 7 | .21 | .02 | .001 | .15 | 7.7 | 5 |
| 29/7/75 | 29 | 39 | 86 | - | 4 | 3 | .21 | .01 | .001 | .12 | 7.1 | 5 |
| 27/8/75 | 30 | 42 | 87 | - | 13 | 5 | .23 | .02 | .002 | .12 | 7.2 | 5 |
| 23/9/75 | 31 | 41 | 90 | .17 | 25 | 8 | .25 | .01 | .001 | .19 | 7.1 | - |

* less than

TABLE 5: Analysis Results for Samples at Station 3

| Date | Alk.-mg/1 | Hardness-mg/1 | Cond.-umhos/$cm^3$ | T-Iron-mg/1 | T-Phos.-ug/1 | S-Phos.-ug/1 | TKN-mg/1 | $NH_3$/N-mg/1 | $NO_2$/N-mg/1 | $NO_3$/N-mg/1 | pH | Colour-Hazen Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13/5/75 | 29 | 41 | 86 | .10 | 10 | 1 | .26 | .01 | .002 | .02 | 7.2 | 10 |
| 30/5/75 | 29 | 40 | 86 | .05 | 5 | 1 | .20 | .02 | .002 | .01 | 7.2 | 10 |
| 1/6/75 | 29 | 40 | 86 | .05 | 2 | 1 | .18 | .01 | .002 | .03 | 7.4 | 5 |
| 2/6/75 | 29 | 40 | 86 | *.05 | 1 | 1 | .18 | .01 | .002 | .03 | 7.4 | 10 |
| 13/6/75 | 30 | 40 | 84 | *.05 | 2 | 1 | .21 | *.01 | .002 | .06 | 7.5 | 5 |
| 25/6/75 | 31 | 41 | 86 | *.05 | 6 | 1 | .25 | .02 | .002 | .02 | 7.8 | - |
| 15/7/75 | 31 | 43 | 82 | - | 7 | 1 | .22 | *.01 | *.001 | *.01 | 7.6 | 5 |
| 24/7/75 | 31 | 39 | 86 | - | 5 | 5 | .21 | .02 | .001 | *.01 | 7.7 | 5 |
| 25/7/75 | 31 | 39 | 86 | - | 2 | 2 | .23 | .01 | .001 | *.01 | 7.7 | 5 |
| 29/7/75 | 31 | 39 | 86 | - | 2 | 1 | .26 | .01 | .001 | *.01 | 8.0 | 5 |
| 27/8/75 | 30 | 43 | 88 | - | 4 | 2 | .24 | .01 | .001 | *.01 | 7.3 | 10 |
| 23/9/75 | 30 | 41 | 85 | .08 | 5 | 1 | .22 | .01 | .001 | *.01 | 7.7 | - |

*less than